July 25, 1933. F. E. FISHER 1,920,155

CORE FORMING MACHINE FOR ELECTRICAL APPARATUS AND METHOD OF MAKING CORES

Filed Oct. 26, 1932 4 Sheets-Sheet 1

Fig. 1.

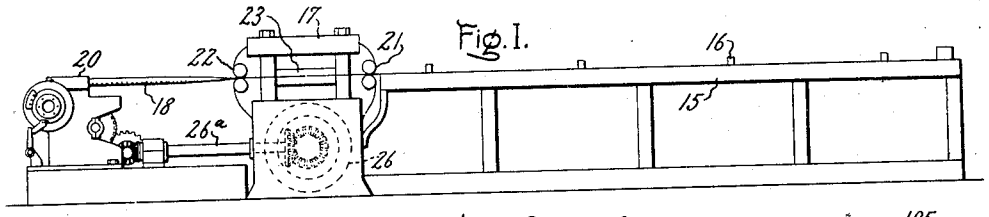


Fig. 2.

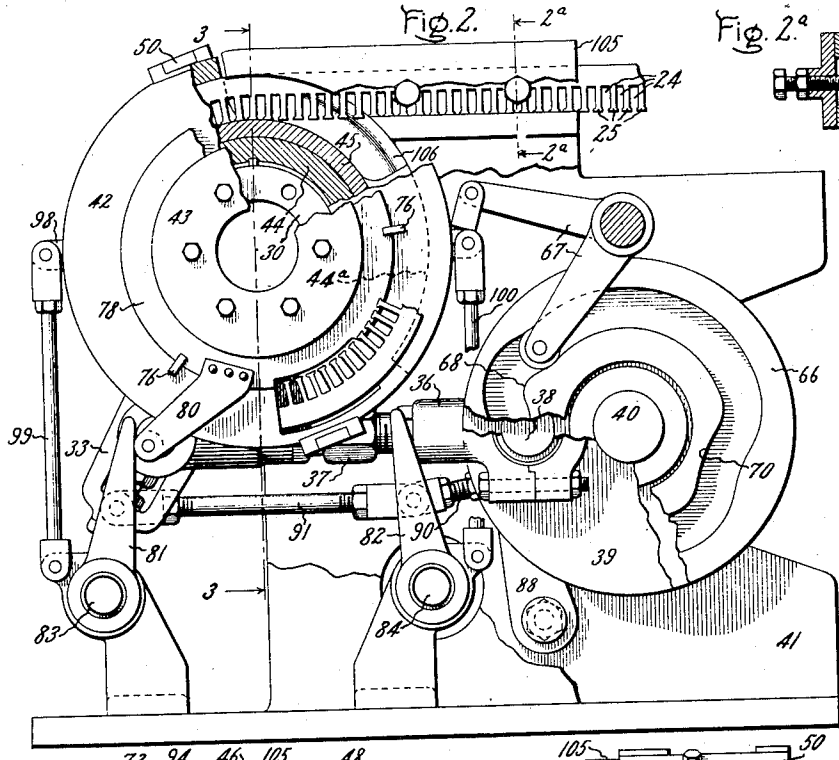


Fig. 2a.

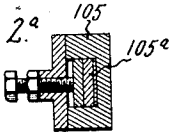
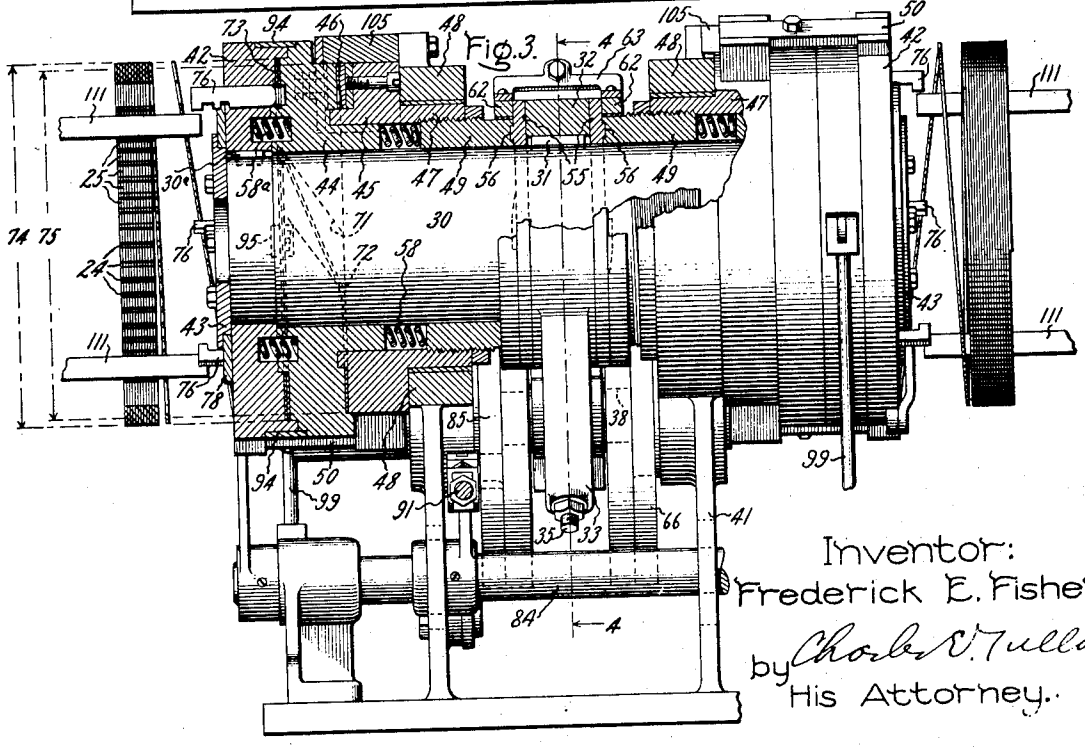


Fig. 3.



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CORE FORMING MACHINE FOR ELECTRICAL APPARATUS AND METHOD OF MAKING CORES

Filed Oct. 26, 1932 4 Sheets-Sheet 2

Fig. 4.

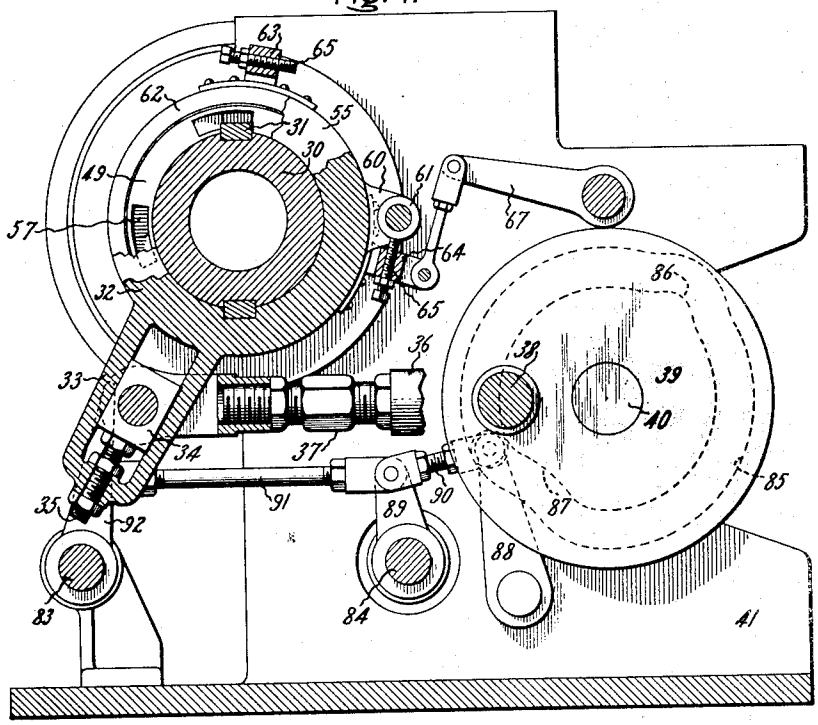


Fig. 5.

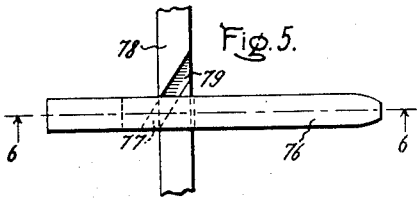


Fig. 9.

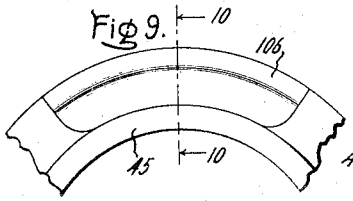


Fig. 10.

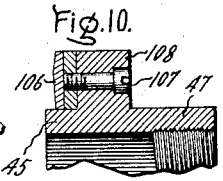


Fig. 6.

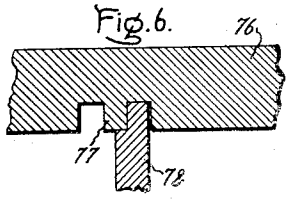


Fig. 11.

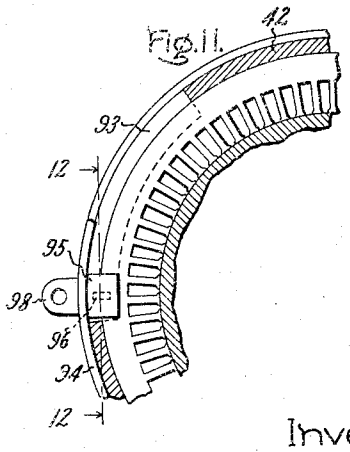


Fig. 12.

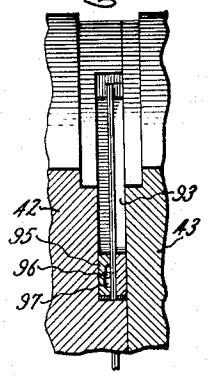


Fig. 7.

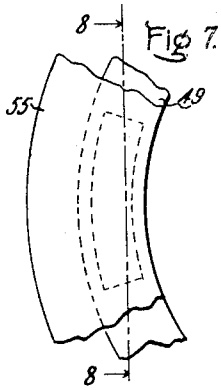
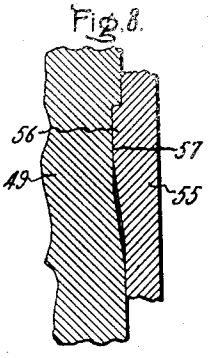


Fig. 8.



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CORE FORMING MACHINE FOR ELECTRICAL APPARATUS AND METHOD OF MAKING CORES

Filed Oct. 26, 1932 4 Sheets-Sheet 3

Fig. 13.

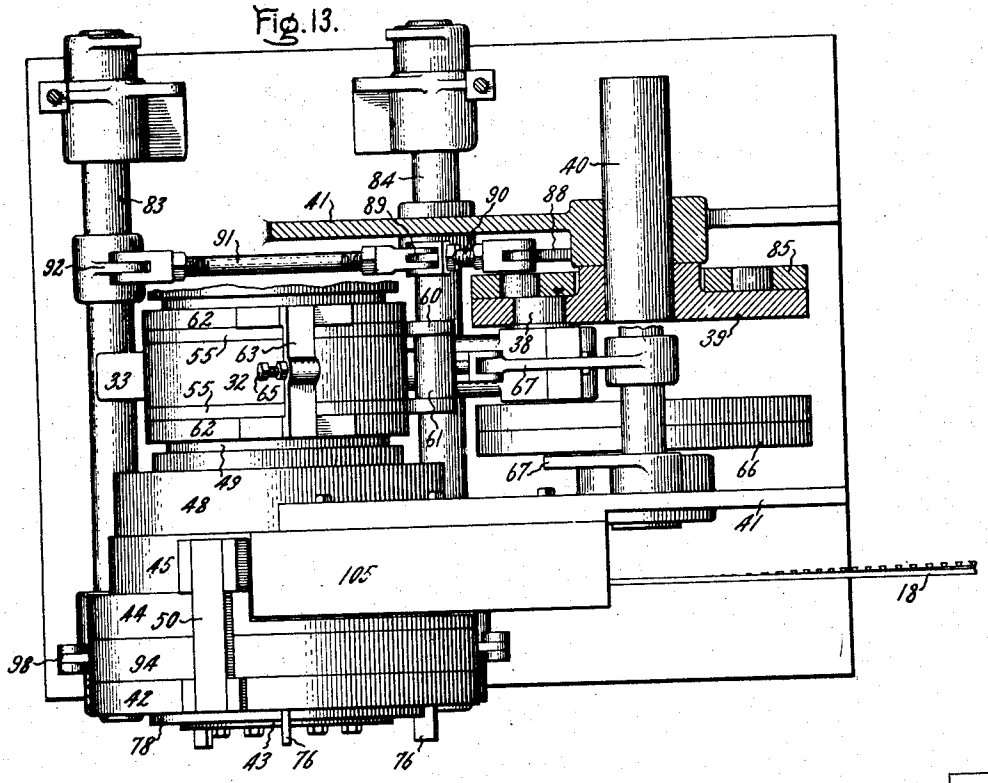


Fig. 19.

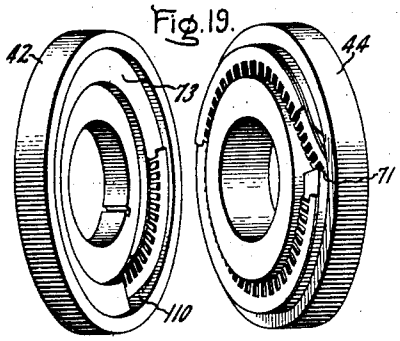


Fig. 15.

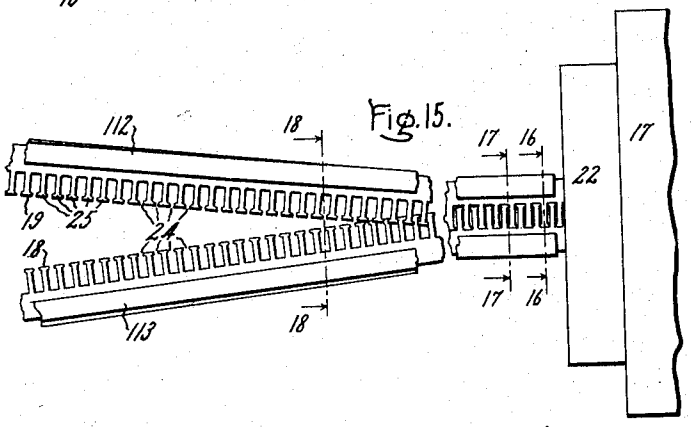


Fig. 16.

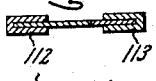


Fig. 17.

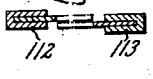


Fig. 18.

Fig. 20.

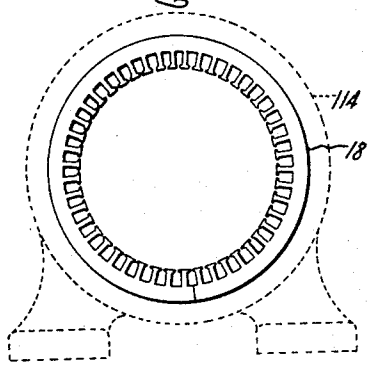
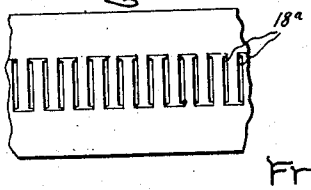


Fig. 14.



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CORE FORMING MACHINE FOR ELECTRICAL APPARATUS AND METHOD OF MAKING CORES

Filed Oct. 26, 1932 4 Sheets-Sheet 4

Fig. 21.

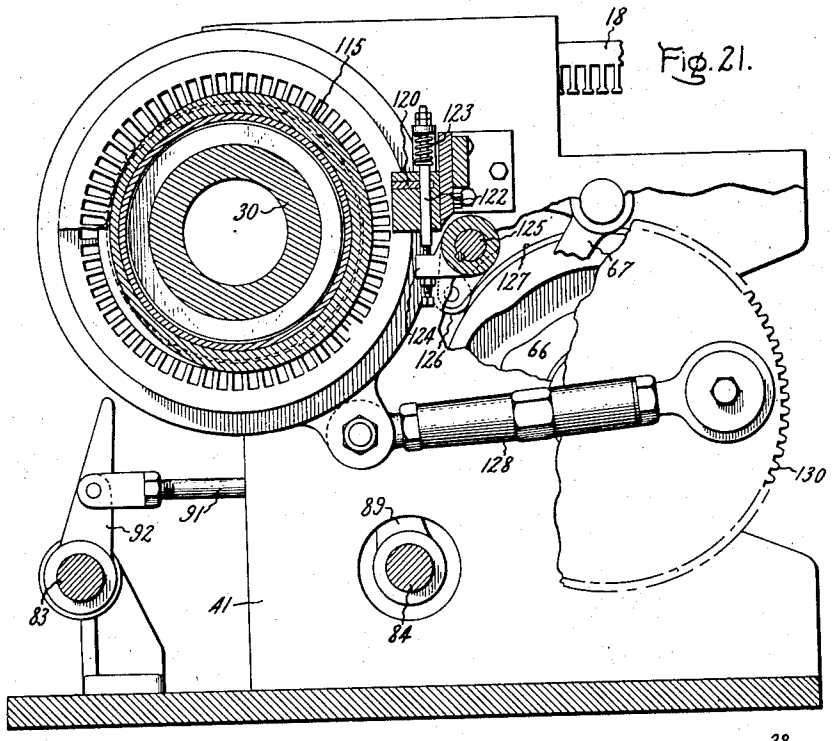


Fig. 22.

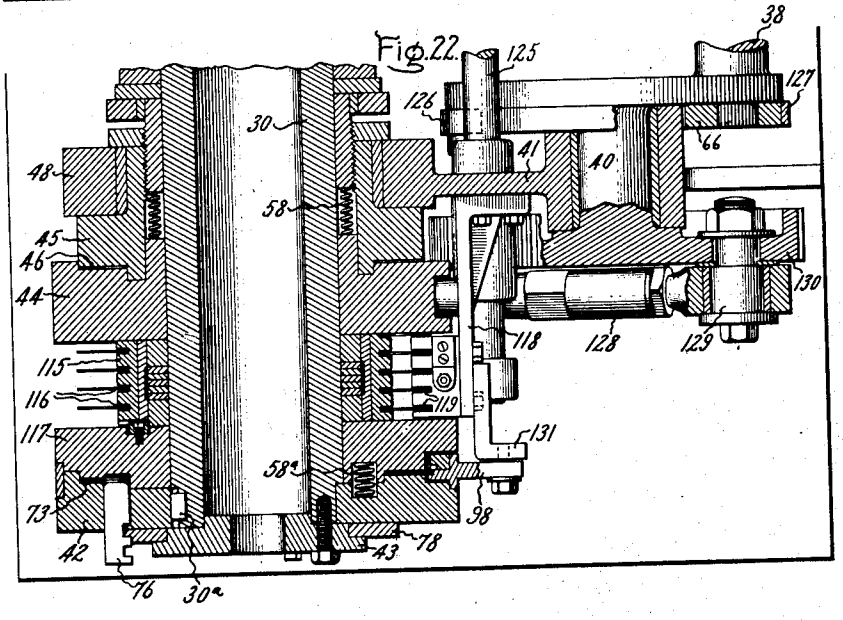
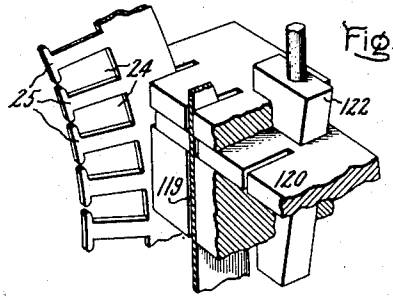


Fig. 23.



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Patented July 25, 1933 1,920,155

UNITED STATES PATENT OFFICE

FREDERICK E. FISHER, OF SCOTIA, NEW YORK, ASSIGNOR TO GENERAL ELECTRIC COMPANY, A CORPORATION OF NEW YORK

CORE FORMING MACHINE FOR ELECTRICAL APPARATUS AND METHOD OF MAKING CORES

Application filed October 26, 1932. Serial No. 639,624.

The accepted practice in the manufacture of cores for electric generators and motors is to punch rings, disks, or segments from thin sheet steel and then to assemble them in a stack to the required thicknesses, which stack is later put in a suitable frame. It is also the practice to punch coil slots with intervening teeth between them at the same time the ring, disk or segment is formed. Punching round or segmental objects from rectangular sheet stock, no matter how economically the stock is used, results in a large amount of scrap material. On account of the fact that the sheet stock, to attain the best results, has to be made of very high grade material, as silicon steel for example, the monetary loss due to the scrap is a substantial item and represents of course an increased cost to the manufacturer and also to the purchaser of the apparatus.

Furthermore, sheet steel as obtained from the manufacturers is not of exactly the same thickness throughout the sheet. As a result of this in assembling the finished pieces into a stack it is the custom to pile a certain number or sets of disks or pieces in place, then to pile a second set on top of the first, but advanced angularly by a certain amount with respect to the first, then add more disks advanced angularly from the second set, and so on. The purpose of this is to average the inequalities in the final assembly and to avoid spaces, even minute ones between disks or laminations. As all steel sheets have a grain, it follows that in an assembly such as referred to above that there can be no uniformity of direction of the grain but the contrary. Lack of uniformity of grain direction and the presence of spaces between laminations give rise to certain electrical losses, and in addition thereto the spaces cause an increase of noise in operation.

On account of the waste of material as previously outlined, it has been proposed to make smooth laminated cores, or those without teeth, by utilizing stock in the form of a narrow strip and winding it edgewise to annular or helical form. An illustration of such a smooth surfaced core is found in the patent to Thomson 356,902, issued February 1, 1887. To compensate for the difference in diameter of the inner and outer edges of the turns of the coil it was proposed to make the turns of wavy or other peculiar shape or to cut notches in the inner edge of the strip with the inevitable result of leaving relatively large spaces between turns. So far as I know, cores constructed in this manner have never gone into commercial use.

It has been the practice for years to use machines for winding copper strips edgewise to form energizing coils for electrical apparatus and fins for heat interchanges, as automobile radiators, etc, but such machines are incapable of winding strips of uniform cross section or thickness and they are also incapable of winding such hard materials as silicon steel of which cores are made. Moreover the problems due to the presence of teeth along one edge of the strip are not present.

The edgewise winding of a strip of steel to form the core structure of a dynamo electric machine presents problems not found in winding relatively soft material, such as copper, into coils. Briefly stated they are due to the hardness of the steel and the difficulty of bending the same without causing injury thereto or the formation of wrinkles, the requirement that the turns of the resulting helix shall be of uniform thickness or cross section from inner to outer edge, and to the requirement that the teeth be moved from the parallel relation they have in the punched stock to the radial relation they have in the finished core with the teeth and coil slots in exact axial register when the core is mounted in its support. A further indication of the problems involved is found in the fact that for a small stator of approximately 13½ inches in diameter approximately 800 feet of strip stock is required, each turn of the helix having 54 teeth and coil slots or a total of approximately 12,000 teeth and a like number of slots.

My invention has for its principal object the provision of improved mechanism for converting steel ribbon or strip stock into finished slotted cores for electrical apparatus ready for assembly in their frames with

their slots and teeth in register. Other objects of my invention are to avoid handling the stock except to start it into the machine and remove the finished product, thereby decreasing the cost of manufacture, and to eliminate all possible waste of said stock. Other and important features of my invention will be referred to hereinafter.

Before entering into a detail description of my improved mechanism, a brief outline of what it does and how it performs some of the principal operations is desirable. To avoid waste the stock is initially made in long strips. The strip is automatically fed into the punch press part of the mechanism which divides it longitudinally into two narrower interlocking strips as it moves therethrough and at the same time a plurality of slots and teeth are simultaneously formed. I form the teeth of one strip out of the stock of that part of the other strip which would normally be cut out for coil slots and wasted, since by so doing a very material saving is effected and practically no metal is wasted. The toothed strips then pass separately into the parts of the machine where they are wound edgewise to form helices and later discharged. The press has definite periods of operation, one where the slots and teeth are being punched and the stock divided, and a second where the stock is being advanced to a new position ready to be acted upon by the dies of the press, the winding or forming part of the machine also has similar and definite periods of operation. The periods of one part of the machine alternate with those of another. When the press is punching and cutting the stock, the winding machine is idle, and when the press is idle the winding machine pulls stock through the press and at the same time winds a certain length of stock into circular form. During these idle periods certain parts of the press and winding machine are moving preparatory to a working stroke. The length of the segmental portion so formed on each working stroke of the winding machine is determined of course in advance and may be varied to suit different diameters of core, radial depth of the core stock, etc. In the present illustration of my invention the stock is advanced 60° about the axis of the winding machine parts on each stroke but the advance may be greater or less. This 60° movement pulls just enough stock into the press to cause the dies thereof to cut the next set of slots and teeth and at the same time preserve the exact pitch distance between them and those made during the preceding operation of the press. The matter of exact pitch relation is of the greatest importance because the core when completed comprises a large number of turns of strip stock and the slots and teeth of all of the turns must be in exact register, otherwise they will not be of the proper size to receive the coils of small wire with which the core is subsequently wound.

On account of the intermittent or step-by-step actions of the press and winding parts, means are provided whereby the winding parts temporarily release the stock as they move forward preparatory to clamping a new section of the stock. To prevent wrinkles and uneven thickness in the finished product the stock is rigidly confined between non-yielding walls which move with the stock during the bending operation and by the same angular amount. In addition to the strip confining walls a smoothing shoe or die is also provided which forms a part of one of the moving walls. The shoe has the effect of preventing the formation of minute wrinkles which would otherwise tend to form and also preventing thickening of the stock in any region. In this connection particular attention is called to the fact that once wrinkles are formed they cannot be smoothed out later. The stock enters the machine tangentially and the shoe is curved in the arc of a circle, the center of which coincides with the axis of the winding machine parts. After the stock is curved it is transferred to a second pair of members and cooperating therewith are devices which accurately control the passage of stock through the machine.

After the helices are formed and prior to being mounted in a machine for use, they are carefully annealed to remove strains in the steel due to the winding and punching operations, particularly the former, for the purpose of reducing electrical losses. This is done in a closed electrically heated furnace in which is constantly maintained a body of hydrogen gas. The helices are first slowly heated for a number of hours until the maximum temperature of the order of 850 deg. C. is reached which is maintained for a period of the order of two and one-half hours, after which the furnace and its charge are permitted slowly to cool.

In the accompanying drawings which are illustrative of my invention, Fig. 1 is a side elevation of a machine for punching and cutting stock into strips, and subsequently winding the strips edgewise to form cores; Fig. 2 is a partial end view of the winding portion of the machine with certain of the parts broken away; Fig. 2ª is a sectional view of the guide for feeding stock to a winding head; Fig. 3 is a partial longitudinal section on the line 3—3 of Fig. 2; Fig. 4 is a cross-section taken on the line 4—4 of Fig. 3; Fig. 5 is a detail view of one of the sizing pins for positioning the turns of the core and means for actuating it; Fig. 6 is a section taken on line 6—6 of Fig. 5; Fig. 7 is a detail view of a part of the means for exerting sidewise pressure on the

winding head; Fig. 8 is a section taken on line 8—8 of Fig. 7; Fig. 9 is a view in elevation of a smoothing die or shoe; Fig. 10 is a sectional view thereof taken on line 10—10 of Fig. 9; Fig. 11 is a detail view showing clutch means acting on the strip after it has passed through the winding head; Fig. 12 is an enlarged sectional view taken on line 12—12 of Fig. 11; Fig. 13 is a plan view of the machine shown in Fig. 2; Fig. 14 illustrates the stock after passing through the punch press; Fig. 15 is a plan view of the means for separating and giuding the two strips of stock after they are formed by the punch press; Figs. 16, 17 and 18 are detail views showing different parts of the guiding means; Fig. 19 is a perspective view of parts of the winding head through which the finished stock passes; Fig. 20 shows a core assembled in a field frame; Fig. 21 is a sectional view of a modified form of the means for receiving and holding the turns of the finished core; Fig. 22 is a partial horizontal section of the same showing means for transferring bent stock from the forming to the receiving members and Fig. 23 is a perspective view of a clamp device for the turns.

15, Fig. 1, indicates a table having a flat surfaced top over which the strip stock passes between suitable feeding rolls 16. 17 indicates that portion of the machine which moves up and down and punches the coil slots, forms teeth and divides the stock into two strips 18 and 19, Fig. 15, with interlocking teeth prior to entering the edgewise winding part 20 of the machine. The division of the stock into two strips with each strip entering a winding head is best illustrated in Fig. 1, 13 and 15. The stock as a single strip enters the part 17 of the machine, which for convenience will be called a punch press, through feeding rolls 21 and leaves it in the form of two strips through the rolls 22. The press may be of the general type known as a Henry and Wright press with such minor modifications as may be considered desirable.

In the press is a multiple die which may be of usual or suitable type and on its down stroke forms a plurality of coil slots 24 and teeth 25, Fig. 2, 14 and 15, and also cuts the stock longitudinally with the outer ends of the teeth in interlocked relation. The press may be driven by any suitable means such as an electric motor and speed reducing gearing 26. On the gear driven shaft is a bevel gear, shown in dotted lines, which drives the horizontal shaft 26a, and the latter in turn drives the winding machine through suitable gearing. From Fig. 14 it will be seen that the only portions of the stock not used are the very small pieces which are removed between the teeth of one strip and those of the other during the punching or cutting operation. These pieces conform in shape and size to the very small slots 18a. As is customary with the type of press to which the present one belongs, it has a downward or cutting stroke, a lifting or idle stroke, and a period between said strokes when the stock is moved forward by the proper amount to cause each succeeding set of coil slots and teeth to have the exact pitch relation with those made in the previous stroke since otherwise these parts would not register when the strips are coiled to form an annulus. The interlocking arrangement of the teeth results in a very large saving in stock for the reason that the metal which would ordinarily be removed to form a coil slot in each strip is with my improved arrangement utilized to form the teeth of the companion strip. Not only is stock saved in this manner but the grain of the stock in the finished laminated core, due to winding, runs in the same direction.

The portion of the machine which winds the strips to form cores is aligned with the press on the same foundation and its operations are properly synchronized with said press. It may be driven by the same source of power as the punch press. In addition to winding the strips this portion of the machine herein referred to as the winding machine also pulls the strips step-by-step through the press at such time as the parts of the die of the press are open and the stock is free.

Because the sheet steel stock is divided longitudinally into two toothed strips, the winding machine is provided with two winding heads, one for each strip. Should it be desired to wind only one strip at a time one of the heads can either be permitted to operate idly or be removed in which case a single strip as distinguished from a double strip will issue from the press. The axis of the winding heads is shown as being horizontal since this simplifies the feeding of a pair of strips thereto but I have constructed a machine in which the axis of the head is vertical.

Referring more particularly to Fig. 3, but also to Figs. 2 and 4, 30 indicates a rock shaft of relatively large diameter on which is mounted and secured by keys 31 an actuator for rocking or oscillating the shaft. In this instance the shaft moves through 60° but the movement may be greater or less, depending upon the amount of stock to be moved and bent on each active stroke. The actuator comprises a hub portion 32, Fig. 4, and a radially extending slotted arm 33. Mounted in the slot is a block 34, the position of which may accurately be adjusted to vary the angular movement of the hub by the adjusting screw 35 and cooperating nuts. Oscillating or rocking movement of the actuator is effected through the connecting rod 36

which is also adjustable as to length by the nut and screw parts 37. The rod is actuated by a wrist pin 38 mounted on a revolving disk 39. The disk is mounted on a horizontal shaft 40 carried in suitable bearings on the frame 41. Rigidly secured to the ends of the shaft 30 by keys, 30ª, Fig. 3, to prevent relative motion are heavy end heads or plates 42 and which are also held against axial movement by end plates 43 that are securely bolted to the ends of the shaft. These end heads absorb the entire end thrust to which the machine is subjected when in operation, and except for difficulties in assembly could advantageously be made integral with the shaft. As the parts on opposite sides of the actuator are duplicates, a description of those on one side will be sufficient.

In order to wind steel stock edgewise to form an annulus or helix, preserve the same thickness throughout each turn from the center or bore to the periphery and prevent wrinkles and thickening toward the inner edge, that portion of the stock undergoing the bending operation must be definitely confined between walls which are exactly parallel to each other and which remain so under heavy pressure. Also the stock must be confined at its top and bottom edges. Furthermore, the walls which confine the stock must all move with it and at exactly the same rate. In other words, there should be no slippage of the walls and stock relatively to each other. The stock enters the winding machine longitudinally, through a channel shaped stock guide 105 provided with an adjustable friction shoe 105ª to cause slight pressure, and the banding and shaping thereof is confined wholly or chiefly to a small area in the region of the entrance, but nevertheless the bent strip should be confined for the major portion of a circle. As will be seen from Fig. 15, the teeth in the strip stock as it leaves the press are parallel to each other and the space or clearance between each two tips is of substantial amount. The bending of the strip while properly confined causes the spaces or clearances between the ends of the teeth to decrease and also causes the teeth to move from parallel to radial positions. By a proper selection of dimensions for the strip, teeth and coil receiving slots, the ends of the teeth may be moved in the bending operation to exactly the position found desirable for the electrical characteristics of the machine utilizing the core. Although I have described the strips as being used to form stator cores with the teeth extending radially inward, the strips may be so wound that the teeth extend radially outward and the cores so formed used for rotors. To carry out the important bending feature of my invention two annular members 44 and 45 are provided and mounted on the shaft 30, Fig. 3 for simultaneous oscillation. They are free to move independently of each other by a small amount in an axial direction on the shaft 30, first to permit of a slight separation on their idle stroke and second to clamp the stock on their working stroke by which the stock is moved through the machine. The two members have interengaging shoulders and between them is defined a restricted channel 46, Fig. 3, in which a single thickness of stock is definitely confined both as to thickness and radial depth. Because the stock enters the channel 46 tangentially, a segmental piece of the center wall of member 44 is removed leaving an entrance space into the channel which space is somewhat greater than the oscillating movements of the members. This cut away or removed portion of the outer wall is indicated by dotted line 44ª, Fig. 2. The walls defining the channel are perpendicular to the axis of the shaft and are hardened and ground with great accuracy. Such walls prevent any thickening of the stock at its inner edge and any thinning of the stock at its outer edge. The member 45 has a cylindrical portion 47 on its right hand side which is supported by a bearing 48 carried by the frame 41, there being a bearing liner between the adjacent surfaces. The portion 47 is internally threaded to receive the ring 49 which is also capable of sliding axially on the shaft. The parts 47 and 49 are prevented from unscrewing by means of a lock nut mounted on the ring 49. The members 44 and 45 which act on the stock must move in unison therewith. To accomplish this the end head 42 fixed on shaft 30 and member 45 are provided with spaced radial lugs on their peripheries and seated between each pair of lugs is a bar 50, best shown at the right hand end of Fig. 3, and in plan in Fig. 13. By this arrangement motion is transmitted by the actuator to the shaft 30, end head 42 and members 44 and 45.

Since the actuator and rock-shaft 30 are arranged to oscillate between certain defined limits, whereas the edgewise winding must produce an annulus or helix of fine pitch and since the rock-shaft is positively connected to the head 42 and members 44 and 45, it follows that on the working stroke the stock must be firmly clamped between said members and that on the idle or return stroke the members must be free to advance without disturbing the stock preparatory to engaging a new part of the stock. Stated another way, the members when clamped pull a certain amount of stock into the machine, then release it and move forward to again clamp another portion of the stock, the actions taking place in alternation. This is carried out by the following means. Between the hub 32 of the actuator and the ring 49 is located a wedge ring or plate 55 having on

its left side face a number of projections 56, Figs. 7 and 8, which act as wedges to force the members 44 and 45 to the left against the head 42 which acts as an abutment or stop on the working stroke, whereby the stock is clamped, said wedges moving into recesses 57 on the return or idle stroke to release the stock. In Figs. 7 and 8 the size of the wedges and slots has been exaggerated for the purpose of illustration. Stated another way cam surfaces are provided between the actuator and the members which are effective for one direction of movement of the actuator but not the opposite. To separate the parts sufficiently to release the stock on the idle stroke, a set of coiled compression springs 58 is provided, comprising several springs angularly spaced about the axis of the shaft 30 to distribute the pressure uniformly. A second set of similar springs 58^a is employed to separate the members which receive the finished coil. A separation of approximately .005" is sufficient for the purpose. The next thing to be considered is a means for causing the wedges or clutches in the form of cam surfaces to move into and out of action at the proper times, i. e., first when the crank pin 38 is at its inner dead center as shown in Figs. 2 and 4, and second, when the pin is at its outer dead center. The operation of the means must be executed very quickly. Referring to Fig. 4, each of the ring-shaped plates 55 which carry the wedges 56 is provided with a short radially extending arm 60 and the two arms are connected by a bridge piece 61 shown as being of rod-like form. In order to move the plates quickly and at the proper times, rings 62, Figs. 3 and 4, are provided and sleeved on the ring members 49, one on each side of the actuator hub, there being a suitable bearing liner between the surfaces. These rings are connected for simultaneous operation by the bridge pieces 63 and 64, Figs. 3 and 4. In each bridge piece is an adjustable screw-threaded stop 65 which act on the bridge piece 61, Fig. 4, carried by the movable side plates 55. In order to move the plates angularly, by a small amount independently of the ring members 49, a cam 66 is provided and traveling in the cam groove is a roller mounted on one arm of a bell-crank lever 67, Fig. 2, the latter having a pivot supported by the frame of the machine. The cam is provided with a small hump or projection 68 to give a quick movement to the bell-crank lever, said hump being so positioned as to come into service when the wrist-pin of the connecting rod of the actuator is on its inner dead center. One arm of the bell-crank lever is connected by a link, Fig. 4, with an ear attached to the bridge piece 64. Assuming the parts to be in the position shown in Fig. 2 and the cam turning clockwise, a quick movement is imparted to the side plates 55 which causes the wedges 56 to force the members 49, 45 and 44 to the left to tightly engage and hold the strip stock. The actuator now comes into action and turns the large shaft 30 and with it the end head 42 and the coil forming members 44 and 45. The actuator is moved by the connecting rod 36 and wrist-pin 38 on the disk 39. This movement continues until the bridge piece 61, Fig. 4 approaches the end of its travel and is very close to or even touching adjustable screw 65 which has been stationary during the period. It is now time to release pressure on the coil forming members which is accomplished by a quick motion of 65 under the influence of the connecting linkage and depression 70 in the cam 39. The motion required for pressure release is in the opposite direction from that required when applying pressure on the coil forming members. The result of the release causes wedges 56 to move into recesses 57 in the ring member 49. This permits the coiled compression springs 58 to separate the parts of the coil forming members 44 and 45, preparatory to the return stroke of the actuator. The action of the stop pin 65 at the top is permitted by reason of the depression 70 in the cam 66, Fig. 2, which is spaced 180° from the hump or projection 68. It is also to be noted that although the springs 58 relieve the side pressure of the members on the edgewise bent stock, the stock is nevertheless held against expansion radially by the parts of the member 45 which surround it both at the inner and outer diameters.

As previously indicated, only a single thickness of stock can be permitted to occupy the channel between the forming members 44 and 45 since otherwise the turns of the core forming material will not be of uniform section which is the most important feature of core forming material.

As has already been pointed out, one of the fundamental features of my improved construction resides in the fact that the members exert heavy contact pressure on the strip stock at all points and move with it at the same rate of speed until fully shaped, and that the bent stock is discharged as rapidly as formed. Because of the necessary heavy pressure it follows that the discharge means must be beyond the region where the bending and shaping takes place since otherwise it would defeat the purpose of the construction. Although a 240° arrangement of the outlet has been shown, it can be varied either way so long as it does not interfere with the bending and shaping. This means that provision must be made for removing stock as fast as it is properly formed. To accomplish this the member 44 is provided with an outlet or discharge means such for example as the relatively

large diagonal slot 71 shown at the left of Fig. 3. The mouth of the slot is displaced angularly from the point of entrance of the stock; as shown, it is approximately 240° from such point. The inlet mouth of this slot is so shaped or rounded at 72 that the formed stock passes easily and freely through the slot into the stock receiving part of the machine. From the discharge end of the slot the finished core material enters an annular receiving channel or recess 73 formed between the end head 42 and the member 44 of the coil former. It will be observed in this case that the member 44 is common to the coil forming means and the coil receiving means, although separate parts may be used.

The finished core material as it passes from between the members 44 and 45 into the receiving channel 73 is well illustrated in Fig. 19. The end head 42 which is fast on the main or rock shaft 30 also has a diagonal discharge opening 110, generally similar to discharge opening 71, through which the finished core material passes, and from which it is received by a core support 111.

I have discovered in forming cores that the diameter of the core and therefor of its forming means should be slightly less than the diameter of the bore of the field frame which ultimately receives the same. The reason for this is that in bending such a material as steel to a predetermined shape, it is necessary to somewhat overbend it to allow for the natural tendency for the metal to spring back. Furthermore, I have also discovered that if radial pressure be exerted inwardly on an open core or helix, such as is formed by the herein described means, the turns, instead of standing perpendicular to the axis of the core and parallel to each other will take a slightly conical form which is objectionable when it comes to assembling the core in its frame. Recognizing the tendency of the core material to spring back as above stated, I make the channel of the core forming parts slightly smaller in diameter than that of the diameter of the finished core. The amount that these parts are made smaller can best be determined by experiment although after reasonable experience in building machines for different diameter cores the proper allowance can be pretty accurately determined. The core receiving channel is of slightly larger diameter than the core as it leaves the forming means. Good practice indicates that the diameter should be the same or slightly larger than the diameter of the core after the "spring back" of the metal. The difference in diameters is indicated by the reference numbers 74 and 75, Fig. 3. If the core is to have a finished diameter of 13½ inches, the diameter of the coil forming channel may be of the order of $13\frac{5}{16}$ inches, for example.

Since no work is done on the core after it leaves the forming means, the core receiving channel may advantageously contain more than a single turn. In practice, it has been found that two turns are satisfactory. The next thing to be considered is how to get the core out of the receiving channel without interfering with other operations, and also to make sure that the proper pitch distance between core slots exists. In other words, to make certain that there is no accumulative error which would cause the teeth and slots in the core to fail of exact axial registration when assembled for use. To this end the head 42, Fig. 3, is provided with what may be termed sizing blocks or pins 76, Figs. 3, 5 and 6, of which there are three angularly spaced apart. These sizing pins or blocks are important for they control the movement of the stock through the machine. They are so located as to give unequal angular divisions of approximately 120° each. For example, in the case of a core having 54 slots, the angular space between one of the pins and the next is equal to the total pitch of 18 slots, and the space between that pin and the next is equal to the pitch of 20 slots, and the space between this pin and the last is equal to the pitch of 16 slots. With the parts so spaced the pins will not successively enter the same slots but will enter different slots thereby ensuring maximum accuracy of control. The number of pins can be changed so long as the angularly spacing is a unit multiple of the core slot pitch. Each pin is of a size to exactly fit into a coil slot and these pins are moved into and out of the coil slots at predetermined intervals. They are quickly moved into the slots at the instant the actuator starts its active stroke and are withdrawn at the instant the actuator starts its return or idle stroke. To properly actuate the pins each is provided with a diagonal tooth or projection 77, Figs. 5 and 6, arranged on its inner side, and engaging with the teeth of the several pins is a cam 78 of ring form having diagonal slots 79, said cam being mounted on the left end face of the head 42, which head oscillates with the main shaft 30. The cam is seated on a shoulder formed on the end plate 43, the latter being bolted to the shaft 30. In order to move the cam at the proper time first to insert the sizing pins and later to remove them, the cam has an arm 80 extending downwardly and to the left as shown in Fig. 2. To move the arm, two levers 81 and 82 are employed, mounted on rock shafts 83 and 84, engagement of lever 81 with arm 80 moves the cam 78 in a direction to release the pins and engagement of lever 82 with the arm inserts the pins. In other words, the sizing pins go into action at the same instant that the strip

stock is clamped in the channel between the forming members 44 and 45 and are withdrawn when said members release the strip stock preparatory to their idle stroke and that of the actuator.

To impart to the arms 81 and 82 the necessary quick action at the periods when the wrist pin 38 is at its inner and also its outer dead centers, a cam 85 is provided as shown in dotted lines in Fig. 4. It has a bump or projection 86 and a low spot 87 displaced therefrom by 180°. 88 indicates an arm pivoted at its lower end on the frame 41 and carrying a roller at its upper end which moves in the groove of cam 85. On the rock shaft 84 is an arm 89 which is connected by an adjustable link 90 with the arm 88 and its roller arm 89 is connected by adjustable link 91 with an arm 92 on the rock shaft 83 whereby the rock shafts and the parts secured thereto move together.

In order positively to move the finished stock or core strip out from the receiving channnel 73 between the main head 42 and the forming member 44, an outlet slot 93 is provided between the parts 42 and 44, Figs. 11 and 12, through which the turns of the finished core pass. In order to exert enough tension on the turns to insure of their free delivery, a ring 94 is provided which rests on shoulders formed on the head 42 and member 44. It is provided with a slotted lug 95 the legs of which engages opposite sides of a pair of turns of the core or stock. This lug is held stationary, proper clearance being provided in the end receiving head 42 and member 43 to permit an oscillating movement of the head and member of approximately 60°. In a slot in one of the walls of lug 95 is a small roller 96 moving in a tapered socket 97. This roller engages the stock frictionally when the receiving head reverses by moving clockwise, and releases the stock when moving anti-clockwise since both winding and receiving heads perform their work during the 60° anti-clockwise oscillation. In other words, a roller type clutch is provided for exerting tension on the turns of the helix during the idle stroke of the coil forming members. The ring 94 is held against rotation by the following means to pull out the stock or core material. On the outer surface of the ring is a lug 98 and to it is attached the upper end of a fixed rod 99, Fig. 2, its lower end being connected to a fixed bracket mounted on the bedplate. The ring 94 is also provided with a duplicate lug and fixed rod 100 on the back side 180° from the first to insure an even or balanced pull on the ring and prevent it from binding.

Returning now to the means for forming or bending the stock to circular form, as shown in Fig. 2, the stock enters tangentially through a relatively long guide 105 which closely fits the strip stock on both sides as well as at the top and bottom thereof. The bending action on the stock takes place practically at the point or region where the lower edge is tangent to the circle defined by the lower wall of the channel. By experience I have determined that if one wall of the channel and for approximately the length of the stroke of the actuator and forming members is very slightly crowned that it improves the product by preventing minute wrinkles which would otherwise form. This is indicated at 106, Figs. 9 and 10, on a greatly exaggerated scale for the purpose of illustration. As a matter of practice the total amount of crown is so slight as to be difficult of measurement, and is formed by a lapping operation which, as is well understood, is only used to remove minute particles of metal. By preference the part so crowned is made in the form of a hardened steel shoe which is removably secured in place by screws 107 and is rigidly backed up by a heavy flange 108 on the forming member, said shoe being slightly longer than the stroke of the forming members 44 and 45. The position of the shoe at the beginning of the working stroke is indicated in Fig. 2. The tendency of a strip when bent edgewise is to thicken at the inside diameter and to stretch and become thinner at the outer diameter. This is prevented by the walls of the channels in the members 44 and 45 which cause a radial flow of the metal of the strip. The crowning of the shoe 106 assists this radial flow of the metal which takes place from the apex of the infinitesimally small trapezoids at the point of bending outwardly to the periphery and prevents the formation of minute wrinkles. The crown on the shoe is located at the place where there is a tendency for ripples to form and a tendency of the stock to thicken which, as will be seen from Fig. 2, is at approximately the bottoms of the slots and beyond the teeth. By the means herein described silicon steel may be so bent as to have a uniform thickness within .0002". It is important that the tendency for wrinkles to form be prevented at the point or region where the edgewise bending begins, for once they are formed, it is practically impossible to remove them by any sidewise pressure which can be exerted on the members 44 and 45 or by any other means.

The score material is cut as indicated in Fig. 14 and because the teeth of one strip are in interlocking arrangement with those of the other strip, it is necessary to provide means for separating them by moving one strip up or down with respect to the other. This is accomplished by means of a pair of guides 112 and 113, Fig. 15, which embrace the bodies of the strips as they issue from the press. One of these guides has a greater

slant and also twist than the other, as indicated in Figs. 16, 17 and 18. In Fig. 16 the guides are in the same horizontal plane. In Fig. 17 guide 113 has been lowered sufficiently to move one strip bodily downward thereby freeing the teeth of the strip of their interlocking arrangement. From this point the strips are gradually twisted so that they may enter the guide 105 which precedes the forming members in a plane perpendicular to that occupied by them in the press.

In Fig. 20 is indicated a complete core mounted in a frame 114 of a dynamo electric machine and by which it is fully supported. The turns of the core may be held between end clamps or the turns may be electrically welded to each other or otherwise united. In the final assembly because the cross-section of each turn at every point is uniform, all of the turns will be flat and in contact over their entire side surfaces.

It may happen that it is desired to wind cores of somewhat different diameter either internal or external or both internal and external or cores having different numbers of teeth and slots. When such is the case, the end head or heads 42 is or are removable and when so removed the original core forming members 44 and 45 may be removed and others having the desired dimensions substituted. A suitable construction for cores of varying diameters is illustrated in Figs. 21 to 23. The principal differences in this construction over the one previously described is the separation of the winding members from the receiving members, the inclusion of a transfer means between the pairs of members, and separate actuators for the winding and receiving members. This arrangement permits of changing the relative working angles of the pairs of members. As the core issues from between the members as previously described it is received by a sleeve 115 which has a spiral groove 116 formed in its peripheral surface and into which the core enters and is there maintained in spaced relation by the walls of the grooves. After leaving the grooved ring it passes through a channel 73 of the same character as that previously described and formed between the end head 42 and an auxiliary member 117 said channel having the appropriate diameter for the coil. In order to permit the stock to advance on the working stroke of the coil forming members 44 and 45 and hold it against backward movement on the return or idle stroke, a bracket 118 is mounted on a suitable part of the frame 41, and on the bracket is mounted a block having as many vertical slots 119 as there are turns of core material on the sleeve 115. In the block is mounted a sliding plate 120 made like a comb and having a registering rectangular opening to receive the wedge 122. Pushing the wedge downward moves plate 120 and causes the walls of its slots to grip or clamp the core stock. The wedge is normally pressed downward into engagement with the plates 120 by the coiled compression spring 123, Fig. 21. The wedge is raised against the spring to release the core stock by an arm 124 mounted on a rock shaft 125, the latter being actuated by an arm and roller 126 from a cam 127. Because of the separation of the forming members 44 and 45 from the head 42, the member 44 in this case is oscillated by a connecting rod 128 and wrist adjustable pin 129 mounted on the side of gear 130 through which rotary motion is imparted to the shaft 40 from the source of power that drives the machine. In these figures the core has a different number of teeth and slots from that shown in the other figures and this requires a different setting of the sizing pins 76 but the means for actuating them is of the same character as that previously described and hence further description is unnecessary.

To the bracket 118 is attached a smaller bracket 131 for supporting the member 98 of the roller clutch mechanism described in connection with Figs. 11 and 12 and acting in the same manner on the turns of the core material located within the channel 73.

Since it is difficult to obtain strip stock of the exact length desired for forming a core, I may unite shorter strips by a welding process. For this purpose atomic hydrogen brazing has proved the most satisfactory, and strips so united will pass through the winding members without fracture or other injury. After the brazing operation, it is desirable to lightly grind the surfaces to remove any burs or other inequalities.

By the mechanism herein described a saving in silicon steel of approximately 50% is effected for a motor of corresponding size. There is also a substantial saving in direct labor, machinery, investment and tools over present practice.

I have disclosed herein the method of cutting a strip of stock into two narrower strips both having teeth and coil slots with the teeth of one strip interlocking with those of the other but no claim is broadly made thereto as it is the invention of Thomas A. Wry and forms the subject matter of his application for patent Ser. No. 639,626 filed October 26, 1932.

I have disclosed herein the method of forming core from strip stock by the use of a punch press and a machine for winding the strip to form a helix but no claim is made broadly thereto as it is the invention of Louis E. Underwood and forms the subject matter of his application for patent Ser. No. 639,622 filed October 26, 1932.

I have described the making of a laminated core structure by passing a toothed strip once through the winding machine as this is entirely satisfactory for many types and sizes of dynamo electric machines. However, there are cases where by reason of small diameter of core structure or greater radial depth of core material, an attempt to bend the stock in one operation to the final diameter would result in destroying it. In such cases the bending is performed by successive stages or operations, each operation being well within the bending limits of the stock. The strip is wound edgewise as described to a substantially larger diameter than is required for the final core and is then rewound to a smaller diameter in the same type of machine, the only difference being that the guide 105 instead of being straight is curved to the same diameter as the coil which is to be rewound. To avoid the necessity of changing parts of the winding machine, it will for quantity production be desirable to use one machine for the initial winding and another machine or machines for the rewinding, the rewinding machines having stock receiving channels of successively smaller diameters. Where the change is from a large to a small diameter core requiring a number of successive operations or stages, I may, when necessary or desirable, anneal the helices in a hydrogen furnace between winding operations but it is desirable to avoid annealing whenever possible on account of the additional expense.

What I claim as new and desire to secure by Letters Patent of the United States, is:

1. In a machine of the character described, the combination of a pair of members mounted to turn on a common axis and presenting opposing flat surfaces, said surfaces being arranged to clamp and retain between them a thin strip of metal lying in a plane perpendicular to said axis, means for simultaneously turning both of the members and the strip to bend the latter edgewise to circular form, means for discharging the strip from between the members after it has been so bent, and a supporting frame.

2. In a machine of the character described the combination of a frame, a pair of members defining between them a channel having rigid top, bottom and side walls, one of said members having a stock discharging means, a guide for feeding stock tangentially into the channel, a means for turning the members on their axis to bend the stock edgewise to circular form and causing the bent stock to pass through said discharging means, and a means for receiving and retaining the stock in coil form after it leaves said means.

3. In a machine of the character described, the combination of a frame, a pair of members for bending stock edgewise to helical form, a support common to the members on which they are capable of independent axial movement, means of causing the members alternately to clamp and release the stock by axial movements, means for oscillating the members in unison, and a means associated with one of the members through which the stock passes after it has been bent to circular form.

4. In a machine of the character described, the combination of a frame, a pair of members mounted to turn for bending strip stock edgewise to helical form, a support for the members, means causing the members alternately to move axially on the support to clamp and then release the stock, a means formed in the wall of one of the members through which the stock is discharged after it has been bent to circular form, a means for simultaneously oscillating the members, a guide for feeding stock tangentially between the opposed faces of the members, and a holder for receiving stock from the discharging means, said holder having a diameter slightly greater than that of the coiled stock as it leaves the members.

5. In a machine of the character described, the combination of a frame, a pair of oscillating members arranged to receive strip stock between them and bend it edgewise, a shaft on which the members are mounted, an actuator fast on the shaft for rocking it, a clutch means between the actuator and members alternately to cause them to grip the stock and release it, power means for moving the actuator, means operating at the ends of the stroke of the oscillating members alternately to actuate the clutch means and release it.

6. In a machine of the character described, the combination of a frame, a pair of coil forming members which between them define a rigid wall channel, a support for the members, a guide for directing strip stock tangentially into the channel, means for turning the members and the stock to bend the latter edgewise to form a helix, means receiving and confining the finished coil as it issues from the members, the diameter of said means being slightly greater than that of the helix as discharged from the members.

7. In a machine of the character described, the combination of a frame, a pair of coil forming members which between them define a channel conforming in shape and size to a single thickness of strip stock, a support for the members, a guide for directing strip stock tangentially into the channel, a means formed in one of the members through which the stock is discharged after being bent to circular form, a pair of members receiving the finished coil from the

forming members, said members defining between them a channel for confining a plurality of turns of said stock, a means formed in one of the coil receiving members for discharging the coiled stock as rapidly as formed, and means for actuating all of the members in unison.

8. In a machine of the character described, the combination of a frame, a shaft, an actuator for oscillating the shaft, a pair of members mounted on the shaft to turn therewith, said members defining a channel between them in which strip stock is confined and bent edgewise, means moved by the actuator for exerting sidewise pressure on the stock during the active stroke of the actuator, and yielding means for slightly separating the members on the idle stroke of the actuator and members.

9. In a machine of the character described, the combination of a frame, a pair of members which define a channel between them, a guide for feeding strip stock tangentially to the channel, means for moving the members and the stock a predetermined angular amount about a common axis to bend the stock edgewise to circular form by successive steps, means for releasing the members from engagement with the stock and permitting them to move angularly independently thereof and subsequently to reengage the stock, and means for discharging the stock from between the members after it has been bent to circular form.

10. In a machine of the character described, the combination of a frame, a pair of members which define between them a channel of a size to receive a single thickness of stock, a guide for feeding strip stock tangentially to the channel, means for alternately moving the members backward and forward by a series of relatively short strokes to bend the stock edgewise to circular form, means for causing the members to clamp the stock on their backward stroke and to release it on their forward stroke, and means formed in one of the members for discharging the bent stock after a predetermined number of said backward strokes.

11. In a machine of the character described, the combination of a frame, a pair of members defining between them a channel for bending strip stock edgewise by successive operations, said stock having alternate teeth and coil slots along one edge, an actuator for oscillating the members, a strip discharging means formed in one of the members, a core receiving channel into which the stock passes from the forming channel, means for causing the members to alternately engage and release the stock, and a means positively to hold the bent stock in the receiving channel during the bending operations.

12. In a machine of the character described, the combination of a frame, a pair of members defining between them a channel for bending strip stock edgewise by successive operations, said stock having alternate teeth and coil slots along one edge, an actuator for oscillating the means, a strip discharging means formed in one of the members, a core receiving channel into which the stock passes from the forming channel, means for causing the members to alternately engage and release the stock, a clutch engaging the core material in the receiving channel, and a means for alternately causing the clutch to engage and release the core material between successive bending operations.

13. In a machine of the character described, the combination of a frame, a pair of members mounted to turn on a common axis and presenting opposing flat surfaces, means causing the members to clamp between their opposed surfaces a thin strip of edgewise disposed metal, a crowned shoe carried by one of the members for engaging the stock for preventing formation of wrinkles, means for simultaneously turning both of the members and the strip to bend the latter edgewise to circular form, and means for discharging the strip from between the members in the form of a helix.

14. In a machine of the character described, the combination of a frame, a pair of pivotally supported members arranged side by side and defining between them a stock receiving channel, a guide for feeding thin strip stock tangentially to the channel in which it is bent edgewise as it and the members turn, a shoe carried by one of the members and forming a part of a wall of the channel, said shoe being slightly crowned to prevent formation of wrinkles in the stock, an actuator for oscillating the members, and means for causing the members to alternately engage and release the stock.

15. In a machine of the character described, the combination of a frame, a pair of members arranged side by side and defining between them a stock receiving channel having rigid top, bottom and side walls, a guide for feeding strip stock having teeth and slots along one edge to the channel, a shoe carried by one of the members and forming a part of the wall of the channel, said shoe having a crown curved in the arc of a circle and positioned to engage the stock in the region above the slots, an actuator for oscillating the members, and means for causing the members to clamp the stock on their working stroke and to release it on their idle stroke.

16. In a machine of the character described, the combination of a frame, a pair of pivotally supported members arranged side by side and defining between them a

rigid walled stock receiving channel, a guide for feeding stock tangentially into the channel in which it is bent edgewise, a support common to the members on which they have a limited axial movement, an actuator for oscillating the members to bend the stock by successive operations, means causing the members to move sidewise on their support to clamp the stock on their working stroke and release it on their idle stroke, and a device acting at the ends of said strokes to insure quick action of said means.

17. In a machine of the character described, the combination of a frame, a rock-shaft, a head secured to each end thereof and acting as abutments, an actuator mounted on the rock-shaft between the heads, pairs of members mounted on the shaft to turn therewith and capable of a small axial movement thereon, each pair of said members defining between them a rigid wall channel to receive and bend strip stock edgewise, means causing each pair of heads alternately to engage and release the stock at the ends of its strokes, and means for imparting reciprocating movement to the actuator.

18. In a machine of the character described, the combination of a frame, a pair of members for receiving strip stock and bending it edgewise to form a helix by successive operations, a second pair of members receiving the bent stock from the first pair, actuating means for oscillating the pairs of members, means for discharging helically formed stock from the second pair of members, and a means for receiving the stock from the second pair of members and holding it in helical form.

19. In a machine of the character described, the combination of a frame, a rock-shaft, a head secured to each end thereof, and acting as abutments, an actuator mounted on the rock-shaft between the heads, pairs of members mounted on the shaft to turn therewith and capable of a small axial movement thereon, each pair of said members defining between them a rigid wall channel to receive and bend strip stock edgewise, means causing each pair of heads alternately to engage and release the stock at the ends of its strokes, means for imparting reciprocating movement to the actuator, and receiving means adjacent each pair of members to receive the core material after it has been bent to helical form.

20. In a machine of the character described, the combination of a frame, a pair of members arranged face to face on a common axis and between them defining a channel of cylindrical form having rigid top, bottom and side walls, a guide for feeding strip stock tangentially into the channel and causing the inner edge of the strip to move gradually into contact with the bottom wall of the channel as the members move angularly, an actuator for simultaneously oscillating the members on their axis to bend the stock edgewise by successive steps to form a helix, means for moving the members axially to cause the walls of the channel to rigidly clamp the stock and move with it on the working stroke of the members, other means to separate the members axially and release the stock on their idle stroke, means for discharging the bent stock from the channel before it makes a complete circle, and devices periodically inserted into and withdrawn from the finished helix for controlling the passage of stock through the machine.

21. In a machine of the character described, the combination of a frame, a rock-shaft, a head rigidly secured to one end thereof, a pair of members defining between them a rigid wall channel in which sheet stock is bent edgewise to form a helix, said members being mounted on the shaft and capable of moving independently and axially thereon, a driving connection between the head and the members, a wedge plate located between the actuator and one of the members to exert sidewise pressure on both of said members and on the stock in the channel, means for moving the wedge plate before and after each stroke of the members, means for separating the members when released by the wedge plate, and means for oscillating the members and the wedge plate.

22. In a machine of the character described, the combination of a frame, a rock shaft, a pair of members mounted on the shaft to turn therewith and defining between them a rigid wall channel for bending sheet stock edgewise by successive strokes to form a helix, said members moving with the stock on their active stroke and releasing it on their return stroke, an actuator secured to the shaft for oscillating it, a connecting rod and disk for moving the actuator back and forth, a cam moving with the disk, and means actuated by the cam for causing the members quickly to clamp the stock at the beginning of their active stroke and quickly to release it at the beginning of their return stroke.

23. In a machine of the character described, the combination of a frame, a pair of members for receiving strip stock and bending it edgewise to form a helix, a second pair of members receiving the bent stock from the first pair, actuating means for oscillating the pairs of members, means causing both pairs of members firmly to clamp the stock on their working strokes and to release it on their idle strokes, and stationary clutch means for engaging and holding the helix during the idle stroke of the members and releasing it during the working stroke of the members.

24. In a machine of the character de-

scribed, the combination of a frame, a pair of members for edgewise bending strip stock having teeth and slots along one edge, an actuator for the members, a means for receiving the stock from the members after it has been bent thereby, and sizing pins carried by the means and arranged to move into and out of slots in the bent stock.

25. In a machine of the character described, the combination of a frame, a pair of members for edgewise bending strip stock having teeth and slots along one edge, an actuator for oscillating the members, a means moving with the members and receiving bent stock therefrom, sizing pins carried by the means, and cam means for axially moving the pins into and out of the slots in the bent stock.

26. In a machine of the character described, the combination of a frame, a pair of members for edgewise bending strip stock having teeth and slots along one edge, an actuator for oscillating the members, a pair of members defining a receiving channel into which the bent stock passes from the forming members, sizing pins carried by one of the members of said pair, and cam means for moving the sizing pins axially into and out of the slots in the bent stock.

27. In a machine of the character described, the combination of a frame, a means for bending edgewise a slotted strip of stock, a pair of members having a common axis and defining a channel between them into which the bent stock enters, sizing pins carried by one of the members at equal radial distances from the axis thereof and spaced from each other by unequal arcs to prevent the pins from successively entering the same slots in the bent stock, actuating means for the strip bending means and the pair of members, and means for moving the pins axially into and out of the slots in the strip at predetermined intervals to control the movement of the stock through the machine.

28. In a machine of the character described, the combination of a frame, a pair of members arranged to receive and bend stock edgewise to form a helix of predetermined diameter, a pair of members forming a receiving channel between them, the diameter of the channel being sufficiently greater than that of the helix as formed to compensate for the spring back of the stock after the bending operation, means guiding the stock from the forming members to the receiving channel, and other means for discharging coiled stock from the receiving channel at the same rate it is received.

29. In a machine of the character described, the combination of a pair of members arranged to bend stock edgewise to helical form by successive operations, a pair of members arranged to receive the turns of the helix as rapidly as they are formed, a means for oscillating both pairs of members simultaneously, means causing the first pair of members to clamp and bend the stock on their working stroke and to release the stock and pass over it on their idle stroke, a supporting frame, a clutch means carried by one of the members of the second pair of members for exerting tension on a turn of the helix during the period of the working stroke of the forming members.

30. In a machine of the character described, the combination of a frame, a pair of members having a channel for receiving and edgewise bending strip stock, means formed in one of the members at a point less than 360° from the point of entrance of the stock for discharging it in bent form, a second pair of members having a channel for receiving the bent stock from the first pair, said channel being of a size to receive and retain more than a single complete turn of the stock, means formed in one of the members of the second pair for discharging helically bent stock at the same rate that it is received, and actuating means for both pairs of members.

31. In a machine of the character described, the combination of a frame, a pair of members defining a channel between them for receiving and edgewise bending strip stock, one of said members having an opening with diagonal walls between which bent stock is discharged after being bent, a second pair of members situated at one side of the first, both of said members having openings with diagonal walls between which the bent stock moves and is guided thereby for receiving and discharging the stock, the receiving openings being aligned with the discharge opening of the first mentioned pair, and means for actuating the members to bend the stock and move it successively through the members.

32. In a machine of the character described, the combination of a frame, a rock-shaft, members mounted on the shaft and defining stock containing channels, one of said channels bending strip stock edgewise and the other receiving it, one of said members being common to both channels and containing an opening with diagonal walls through which bent stock moves from the forming to the receiving channel, an actuating means for the rock-shaft, and means causing the members simultaneously to clamp and move the stock on their working strokes and to release it on their idle stroke.

33. In a machine of the character described, the combination of a pair of members for bending stock edgewise to form a helix by successive operations, a second pair of members for receiving the stock after it is bent, a means located between the pairs of members for transferring stock from one of the pairs to the other and maintaining it in

helical form during the transfer, actuating means for simultaneously oscillating the pairs of members and the transfer means, and means causing the members and means to pull the stock on their working stroke and release it on their idle stroke.

34. In a machine of the character described, the combination of a pair of members for bending stock edgwise to form a helix by successive operations, a second pair of members for receiving the stock after it is bent, a ring having a spiral groove for receiving the bent stock from the first pair of members, holding it in helical form and transferring it to the second pair of members, means causing the members alternately to clamp and release the stock, and actuating means for oscillating the members and ring.

35. In a machine of the character described, the combination of a pair of members for bending stock edgewise to form a helix by successive operations, a second pair of members for receiving the bent stock, means for transferring the stock from the forming to the receiving members, a separate driving means for oscillating each pair of members, and means acting to move the members of each pair to clamp the stock on their working strokes and to release it on their idle strokes.

36. The method of forming a laminated structure for a dynamo electric machine which comprises cutting alternate teeth and slots in a strip of metal stock, winding the strip edgewise to from a helix of a predetermined diameter, rewinding the helix so formed to a helix of smaller diameter with the teeth and slots in axial register, and annealing the helix before use to remove strains.

37. The method of forming a laminated structure for a dynamo electric machine which comprises cutting alternate teeth and slots in a strip of magnetic stock, winding the strip edgewise to form a helix of predetermined diameter having turns of uniform thickness from edge to edge and the teeth and slots in axial register, and rewinding the helix so formed to a helix of smaller diameter and preserving in the rewinding operation the axial arrangement of teeth and slots determined by the first operation.

38. In a machine of the character described, the combination of a press having an active and an idle stroke for cutting teeth and slots in a strip of metal stock, a machine for winding the stock edgewise also having an active and an idle stroke, said winding machine acting to pull the stock through the press and also bending it during the idle stroke of the press, said press cutting said teeth during the idle stroke of the winding machine, and means for driving both the press and winding machine.

39. In a machine of the character described, the combination of a press having an active stroke for cutting teeth and slots in a strip of metal stock and an idle stroke for releasing the stock, members engaging the stock for pulling it through the press on its idle stroke and also bending the stock edgewise and preserving its uniformity of thickness, means releasing the members from engagement with the stock during the active stroke of the press, and driving means for the press and members.

40. In a machine of the character described, the combination of a press having an active stroke for cutting teeth and slots in a strip of metal stock and an idle stroke for releasing the stock, oscillating members engaging the stock and pulling it through the press by successive steps, said members bending the stock edgewise to circular form, means forming a part of the members for preserving the uniformity of section of the stock during the bending operation, means causing the members alternately to clamp and release the stock, a means for actuating the press, and a means for simultaneously oscillating both of said members.

41. In a machine of the character described, the combination of a press for dividing a piece of stock longitudinally into a pair of strips and cutting teeth and slots in both strips with the teeth of one strip occupying the slots in the other strip, pairs of members for winding the strips edgewise to form separate helices, means for actuating the press and said means, and a device for separating the strips and removing the teeth of one strip from the slots of the other after the divided stock leaves the press and before it enters the winding members.

42. In a machine of the character described, the combination of a press for dividing a piece of stock longitudinally into a pair of strips and also cutting teeth and slots in both strips with the teeth in interlocking arrangement, a means for directing the stock into the press, pairs of members having a common axis for winding the strips edgewise to form separate helices, means for actuating the press and members, a device for moving one strip relatively to the other in a plane perpendicular to the flat surface thereof to separate the teeth of one strip from the slots of the other, and guides which twist each of the strips prior to being acted upon by a pair of members.

43. In a machine of the character described, the combination of a press for cutting a width of metal stock longitudinally into two narrow strips and also forming teeth and coil slots with the teeth of one strip located within the slots of the other strip, means for separating the two strips to disengage the teeth of each strip from the walls of the slots of the other strip, pairs of

members receiving the stock so divided and winding it edgewise to form independent helices with the teeth and slots of each in axial register, and a means for simultaneously driving both pairs of members at the same speed.

44. The method of forming cores for electrical apparatus which comprises taking straight strip stock of magnetic material, cutting alternate teeth and coil slots along one edge, bending it edgewise to form a helix of slightly smaller diameter than its receiving frame to compensate for the spring back of the material when released, and confining the strip at all points during the bending operation to preserve uniform section of the material.

45. The method of forming cores for electrical apparatus which comprises taking straight flat stock of magnetic material, cutting alternate teeth and coil slots along one edge, bending the stock edgewise to form a helix by a series of successive steps, and maintaining the section of the stock uniform during each of the bending steps.

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